TEXTILE RESEARCH INSTITUTE

ANNUAL REPORT

1959

30TH ANNUAL REPORT

TEXTILE RESEARCH INSTITUTE

PRINCETON NEW JERSEY

1959

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MESSAGE FROM THE CHAIRMAN

In accord with the tradition that the Chairman of the Board of Textile Research Institute report annually to the Trustees and Membership, it is a pleasure to review the Institute's activities in 1959, the thirtieth year of its operation. It is most gratifying to note that there has been no diminution of effort in the performance of the Institute's three principal functions—basic research, graduate training of scientists, and diffusion of knowledge. Furthermore, TRI operated in 1959 with a balance between income and expenditure; in fact, a small but definite operating surplus developed. It should be remarked that 1959 was the first year in which the realistic deferred income accounting system was in full operation; thus, a large part of the funds received in 1959 has been deferred into 1960 income. Actually, we began the new year with nearly half the budgeted income for 1960 already received; this is a new situation for TRI which should make pleasant reading for the Trustees and membership.

Attainment of this rather happy state was not accidental, nor was it simply the result of improved business conditions in the textile industry. TRI's balanced budget in 1959 was achieved mainly through careful planning by the Board, improved budgetary control by the staff, and development of additional income by continuous cooperative pressure of Trustees *and* Staff. By practicing strict economies in the light of mounting costs due

to inflation, operating expense for 1959 increased by only 3% over 1958 ($439,600 as compared to $426,000). Operating income, however, was increased by 18% ($66,700) over that of 1958, and therein lies the story of 1959's balanced operating budget.

The lesson provided by this experience in 1959 can also be read in the history of other years. For TRI to function properly, we cannot back-track in expenditure, aside from assuring sound economy in staff operation. In fact, we must expect and encourage expenditures to increase from year to year, so long as this is consistent with good budgetary control and a sound expanding program. But *we must maintain a pattern of increasing support.* In 1959 this was accomplished by establishing research fellowship grants, bringing in new members, and readjusting our overhead charges so that Special Projects bore a greater share of the over-all load. Clearly we should continue our efforts to expand support by these means and others which are now under consideration by the Board.

Several significant events have occurred in 1959. After careful study by the Committee on Bylaws and Rules and the Committee on Long-Range Planning, the Board recommended a change in the Bylaws which gives a clear distinction between the corporate and the operational functions of the Institute management. This change was ratified by the membership and we now have the Chairman and Vice Chairman of the Board and the Chairman of the Finance Committee as corporate officers, while the President (formerly called Director) and Secretary-Treasurer (formerly Secretary and Assistant Treasurer) are the operations officers. Another important action of the Board was the elimination of "ancillary dues categories." Henceforth all company members will pay dues on the basis of total net sales, thus removing what had become a serious problem in admitting into membership companies with interests not wholly in the textile field. The Committee on Staff Policies made a comprehensive survey of staff pension plans and, upon their recommendation, favorable Board consideration was given a plan which went into effect on January 1, 1960. This move will undoubtedly make TRI much more competitive in maintaining staff continuity and attracting new men.

Enough cannot be said for the enthusiastic work of the Executive Committee under the chairmanship of Russell W. Peterson. He and his committee have met frequently to boil down the ingredients of important brews to make them palatable for action by the full Board. Likewise, Bruce B. Allen, Chairman of the Finance Committee, has kept closely in touch with

all aspects of TRI finances and, largely through his advice, the Institute has operated "in the black" without contraction of operations.

It has been a real inspiration to work with a Board of Trustees, all busy men and all willing to give their time to the affairs of TRI. They have solved a number of problems in 1959 and are working hard to solve others. The staff which, of course, is the core of the Institute, has functioned with its usual ability and enthusiasm; without this, TRI would have little meaning. Our President, Dr. Dillon, continues to give the rare type of leadership which bridges the gap twixt Board and scientist that is so essential in an organization such as TRI. Space forbids individual commendation of his several key men, but it must be mentioned that the entire Board is happy to have Paul Alford, Secretary-Treasurer, back at his post and pulling his full load after a severe illness early in 1959.

To conclude, TRI's record in 1959 engenders optimism for the future. Many problems remain, not the least of these being the long-term deficit which we must somehow, sometime eliminate. But, even more important, we must grow in activity, and this means a bigger staff, more graduate students, and enlarged facilities. It has been demonstrated that there is a place for TRI in the "textile sun" and it is up to us, as Trustees, to put TRI in its proper orbit.

Cordially,

William E. Clark

WILLIAM E. CLARK
Chairman of the Board

REPORT OF THE PRESIDENT—1959

Introduction

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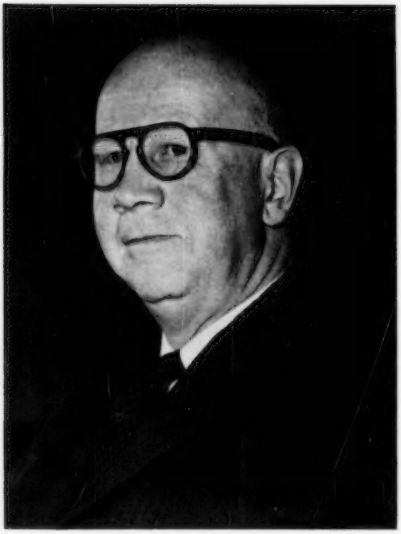


J. H. Dillon

Mr. William E. Clark, in his *Message from the Chairman,* has given a very complete account of the march of events as they relate to the *corporate side* of TRI in 1959. It thus devolves upon the President to report upon the *operations* of the Institute and elaborate somewhat on the subjects of support and finances. It will be noted that this report has been built around the three main objectives of TRI: (1) conduct of long-range basic research; (2) training of scientists at the graduate level; and (3) dissemination of research information. In our efforts to speed the technical advancement of the textile and allied industries it seems well to examine the Institute's performance carefully and frequently in relation to these three principal aims.

TRI RESEARCH

General Program

The General Research Program is that part of our research effort which derives its support from membership dues, fellowship grants, and occasional unrestricted research grants. The major part of the program consists of the very long-range assignments of Predoctoral Research Fellows, Postdoctoral Fellows, and Visiting Fellows. Full-time staff members as well as Research Associates participate, usually as thesis advisors. Support for the General Program improved in 1959 through a modest increase in membership dues income and the initiation of several fellowship grants. Because of increasing

appreciation of TRI graduate education and the fact that reduction of the long-term deficit can be made only by developing a surplus in General Program Funds, neglecting possible grants specified for this purpose, efforts to increase General income by trustees and staff will be intensified in 1960.

Sponsored Projects

Research projects sponsored by groups of members, government agencies, and individual member companies continued in 1959 to be much the largest TRI activity. Income from sponsored projects in 1959 was about $262,000, which represented a 19% increase over 1958 income in this category. No group-, government-, or individual member-supported project is undertaken without assurance that significant results may be published. Thus this program is consistent with TRI policy to confine our research to the basic, long-range type and is manifestly healthy, providing the expenditure on each project is kept within the budget.

A complete listing of group- and government-sponsored projects with data on support level, sponsorship, objectives, etc., is given in the Appendix of this report. The project supported by the International Wool Secretariat (IWS) is also listed, since this program is more of the nature of a group-supported project, although technically it represents the interest of a single Active Member, Wool Bureau, Inc. Another project, supported by Kimberly-Clark Corporation, is included with the consent of the sponsor. Projects individually sponsored in 1959 by Esso Research and Engineering Company and Frenchtown Porcelain Company are not included. It will be noted that a new group project on wool entitled "Supercontraction and Permanent Set of Keratin Fibers" was initiated late in 1959 at a considerably higher support level than was enjoyed by the Industry Wool Research Project, which terminated September 30.

Research Staff

A very conservative policy concerning recruitment of senior staff was pursued in 1959 as a natural consequence of the budget deficit of 1958. Thus, when Dr. James H. Wakelin left to assume the post of Assistant Secretary of the Navy, a large gap in the ranks resulted. Mr. William Virgin resigned late in the year to accept a post in the computation group of Battelle Memorial Institute but fortunately Mrs. Hedwig Knauer had already taken

Senior staff members Dusenbury, Rebenfeld, Lyons, White, and Schwenker discuss research programs.

over the operation and programming of our Bendix Computer and, with the help of Professor Whitwell and others of the staff, has carried out this function very well.

A great deal of credit must be given to our current group for their unstinting efforts to keep all phases of the research program going. With new major projects in the offing for 1960, additional senior people must be found and, above all, we must make every effort to hold our current group. The insurance and major medical plan instituted in 1958 and the newly adopted staff pension plan are plus factors for both staff continuity and growth. Yet it must be recognized that competent scientists are not easy to attract in these exciting days of space research, plasma physics, and rocket fuels development.

A listing of Institute personnel as of December 31, 1959 is given in the Appendix.

General Research Advisory Committee

The General Research Advisory Committee has continued in 1959 to serve its several useful functions: periodic review of the TRI research program, critical discussion of research approaches and results, and recommendation of program changes and additions. The personnel of the Committee as of December 31, 1959 is listed in the Appendix.

The Committee met at TRI on June 1, 1959 under the Chairmanship of Dr. Wayne A. Sisson of the American Viscose Corporation. In an introductory summary of the Committee's activities in recent years, the President listed several major GRAC recommendations which had resulted in new

programs at TRI in the following fields: fiber fatigue, chemistry and physics of minimum care treatments, studies of fiber surfaces, and high temperature degradation of textile materials. The Director of Research then discussed briefly a number of research assignments of the General Program. More detailed presentations were then made as follows:

1. Differential Thermal Analysis of Textile Materials and Textile Coatings—R. F. Schwenker, Jr. (Staff)
2. The Structure of Xanthates of Glucose and Cellulose—John J. Willard (Research Fellow)
3. Extension of Crimped Elastic Filaments—Ricardo Chicurel (Research Fellow)
4. Low Temperature X-Ray Studies of Crystalline Polymers—James H. Wakelin (Staff)
5. Crimp in Man-Made Fibers—W. James Lyons (Staff)

The meeting was characterized by the usual informal discussion of these and other research topics by the Committee. At the close of the meeting, Dr. Sisson was complimented for his work as Chairman during the past two years and Dr. Norman A. Armitage of Deering Milliken Research Corporation assumed the chair. Mr. Edward Lawrence of Cranston Print Works Company was elected Vice Chairman for the period 1959-61.

Patents

The revised patent policy of Textile Research Institute, developed by the Committee on Patents and approved by the Board in 1958, has proved very satisfactory thus far. It is referred to frequently in negotiation of new projects and when firms are considering Active Membership. On the thesis that TRI patent policy is now quite well established, Chairman Clark suggested that the Board Committee on Patents had discharged its responsibilities and that an Advisory Committee on Patents be established to guide the staff and Board in applying for and prosecuting TRI patents. The President appointed this Committee (see Appendix) under the Chairmanship of Mr. George Fremon, Patent Coordinator of Union Carbide Chemicals Company. Other members of the Committee include Trustees John J. Hanlon, Robert M. Jones, GRAC Chairman Norman Armitage, and TRI Patent Attorney Albert Sperry.

Only one TRI patent was actually issued in 1959: U.S. Patent 2,868,744, January 13, 1959, to Howard J. White, Jr. and David M. Cates, "Cellulose—

Containing Polymeric Materials and Method of Producing the Same." Several other applications are in advanced stages with some claims allowed.

Applying for patents is a costly business, and policing licensed patents would not be easy for an organization such as TRI. Hence, we apply for a patent only when the invention seems to have high potential value and where this seems necessary to protect the interests of TRI members or project sponsors.

H. J. White, Jr.

Research Results

The following report of TRI research findings in 1959 was prepared by the senior research staff with the Director of Research serving as editor.

As in last year's report, the research work of the Institute has been separated into four categories: General, Chemical, Physical, or Mathematical Studies and Techniques; Structure and Physical Properties of Fibers; Chemistry of Fibers and Fibrous Systems (Including Dyeing and Finishing); and Fiber Assemblies and Textile Structures (Including Mechanical Processing). The allotment of research programs into the various categories is, necessarily, somewhat arbitrary, with the result that closely allied programs are sometimes in different categories. Anyone wishing a comprehensive picture of the Institute's work in a given field should scan all categories. The first category contains, in addition, all programs of such a general or theoretical nature that they do not fit clearly into one of the other categories.

The sponsor and investigators are listed for each program; complete details on the work of a program can be obtained through the project leader, who is usually listed first. Lists of papers presented or published and the titles of *Notes on Research* are given in the Appendix of this report. The research

programs of the graduate students are also included. In the case of first or even second year graduate students, course work and preparation for examinations may have limited work on the research program to background reading and preliminary experiments.

GENERAL, CHEMICAL, PHYSICAL, OR MATHEMATICAL STUDIES AND TECHNIQUES

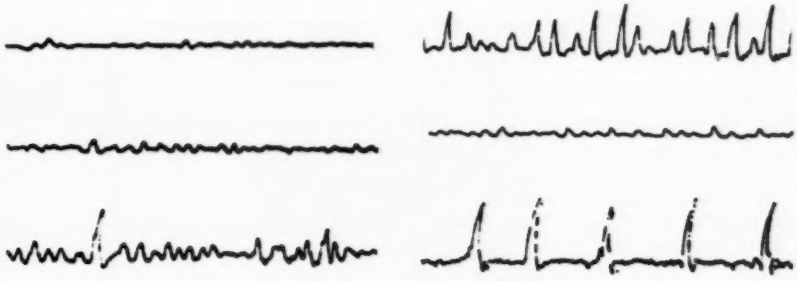
CHARACTERIZATION OF FIBER SURFACES

The development of a stable, sensitive instrument for studying the regularity of a fiber's surface has been described previously. This instrument has been used to obtain information about the surfaces of some forty natural and man-made fibers. Work is currently in progress on the interpretation and utilization of the experimental results obtained. In this connection the charts for the surfaces of animal fibers are important, since the spacing and height of the scales can be measured in other ways and provide means of obtaining calibration factors. The range of smoothness of surface runs from Brazilian silk, high-tenacity viscose, and glass to the rough animal fibers.

In a more detailed investigation of cotton fibers, surfaces of single fibers from Supima and Karnak yarns in both grey and mercerized conditions have been studied. In both of these cottons the effect of mercerization is to decrease the frequency of irregularities and also to decrease the average slope of these irregularities. The effect of other chemical treatments as well as mechanical treatments on cotton fiber surface characteristics will be investigated.

SPONSORS: TRI General Research and Industry Project on Cotton Research

INVESTIGATORS: A. Busacca, Post-Doctoral Fellow, W. J. Lyons, L. Rebenfeld



Surface traces of selected fibers. The traces are not surface profiles but are closely enough related that roughness of the trace is indicative of roughness of the fiber. From upper left: High Tenacity Viscose, Nylon, Semidull Nylon, Raw Cotton, Mercerized Cotton, Medium Wool.

APPLICATION OF RADIOISOTOPES IN THE TEXTILE FIELD

A survey of potential uses of radioisotopes in the textile field is being carried out. Emphasis has been placed on potential uses for production and control rather than in experimental investigations. Uses can be broken into four categories: radiation gauging, irradiation, use of tracers for control, and static dissipation. Of these categories, the first two seem the most promising, with the greatest variety of possible uses falling into the first category.

SPONSOR: Office of Isotopes Development, United States Atomic Energy Commission

INVESTIGATORS: H. J. White, Jr., L. Rebenfeld

REFERENCES: H. J. White, Jr. "Radioisotope Techniques in the Textile Industry," presented before the Annual Conference of the Atomic Industrial Forum, Washington, D. C., November 1959

THERMAL EXPANSION COEFFICIENTS OF THE CRYSTALLINE REGIONS OF HIGH POLYMERS

By use of a recording x-ray diffractometer, the lattice parameters of the oriented crystalline regions in a number of polymers have been measured between −196° C. and room temperature.

Earlier measurements made at these temperature extremes showed a range of large positive thermal expansion coefficients for interchain directions and a negative coefficient along the chain direction for such materials as cotton cellulose, Dacron,* nylon 6, nylon 66, polychloroprene, and rubber.

Recently lattice parameters have been calculated from measurements made at intervals of 10° C. to 15° C. over this temperature range. It was found that rubber showed a sharp change in crystalline expansion coefficients in the region of the second order transition temperature. The interchain coefficients increased from 40 to about 250 $\times$ 10^{-6}/° C., while along the chains a change from zero to -130×10^{-6}/° C. was observed.

Similar measurements have been made on selected well crystallized samples of

The utility of the Institute's x-ray diffraction apparatus has been increased by addition of automatic scanning and recording equipment for use with the counting equipment. The counting tube is automatically driven through the desired range of angles and the intensity of the diffracted beam is plotted on the recorder. Low temperatures are obtained by using liquid nitrogen contained in a vessel, a small part of which is visible (extreme left).

high and low density polyethylenes, ramie, isotactic polypropylene, and Teflon.* In each case the interchain parameters were found to increase with the degree of lattice strain and disorder. Measurements on samples chosen for minimum lattice strain, as shown by the presence of sharp higher order Bragg reflections, revealed an almost linear increase in interchain distances with increase in temperature in each case except for Teflon.* Expansion coefficients were in the range 100–150 $\times 10^{-6}/°$ C., except for 40 $\times 10^{-6}/°$ C. for ramie (which has interchain hydrogen bonds). Teflon* showed a change from almost zero to 120 $\times 10^{-6}/°$ C. at about $-100°$ C. In each case the expansion coefficient measured along the chain direction was zero, except for Teflon* at the room temperature first order transition. The change from zero to a negative expansion along the chains appears to be associated with the change from a system showing three-dimensional order to a "liquid crystal," smectic state.

SPONSOR: Office of Naval Research

INVESTIGATORS: J. H. Wakelin, A. Jefford, H. J. White, Jr.

REFERENCES: J. H. Wakelin "Low Temperature X-Ray Studies on Polymers," Seminar, Textile Research Institute, April 1959

*Du Pont trademark.

ANALYSIS OF STRESS-STRAIN MEASUREMENTS

The objective of this program is a study of the dependencies of the various measurements which can be taken from stress–strain curves on each other and on parameters such as the fiber type or the method of straining. Of the various methods of correlation which might be useful, factor analysis has been chosen and investigated extensively with respect to its applicability and utility.

SPONSOR: TRI General Research

INVESTIGATORS: A. Fiorelli, Second Year Graduate Student in Chemical Engineering, J. C. Whitwell

MONOGRAPH ON IMPACT PHENOMENA IN TEXTILES

An extensive bibliography pertaining to experimental and theoretical research on the important subject of the impact behavior of textiles has been accumulated. With this material as background, the outline of the projected monograph on the subject has been fairly well crystallized. The proposed topics to be covered include an introduction to the mechanical and deformational properties of materials in general, impact testing apparatus for both longitudinal and transverse action, theory of deformation under high-speed impact, related dynamic properties, factors having a bearing on applications, and applications to personnel armor, safety lines, climbing ropes, etc. The initial drafts of a number of chapters dealing with certain of these topics have been written.

SPONSOR: Quartermaster Research and Engineering Command, Department of the Army

INVESTIGATORS: W. J. Lyons, W. P. Virgin

FRACTIONATION OF POLYMERS BY SELECTIVE ADSORPTION

The technique of fractionating polymers by selective adsorption on activated carbon which proved successful with cellulose acetate is being investigated for use with cellulose nitrate. Preliminary experiments showed that fractionation of the nitrate should prove possible; however, for the most part there is no information on the process variables and the mechanism of separation.

To optimize conditions for fractionation and to study the mechanism in as short a time as possible, an experimental design has been developed for dealing with a large number of variables. The design appears to require a program involving three major stages with selected portions of each stage carried on into the subsequent stage. The design is complete and current experimental work involves preliminary study of the operable ranges of the nine variables considered.

SPONSOR: TRI General Research

INVESTIGATORS: R. P. Teulings, Advanced Graduate Student in Chemical Engineering (Johnson and Johnson Fellow), J. C. Whitwell

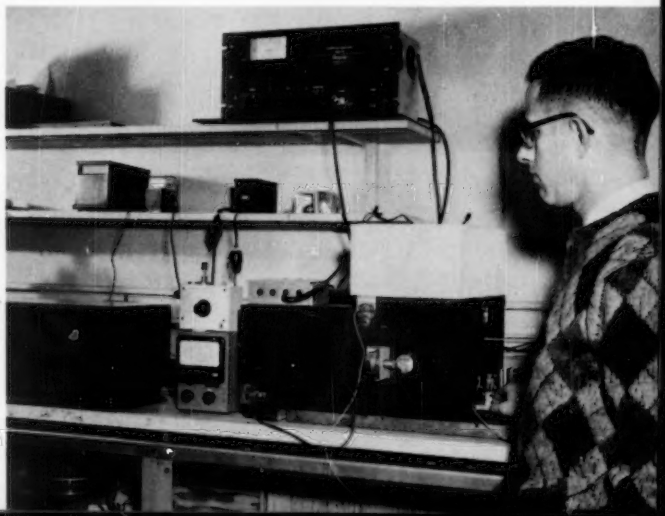
TRANSPORT OF SOLUTE ACROSS LIQUID-LIQUID AND LIQUID-POLYMER INTERFACES

When a molecule of a solute, such as a dye, crosses a phase boundary, such as the one between a nonporous fiber and a dyebath, it passes through a region having unique properties—the interface. Although the interfacial region is small in size, it is possible that it exerts an appreciable effect on the kinetics of the diffusion process. By use of the solutions to the appropriate diffusion equations (which had been obtained previously), a method has been devised to determine experimentally whether or not an interfacial barrier has an appreciable effect on the transfer process.

Equipment has been assembled to make experimental measurements on the transfer of a disperse dye between water and a hydrophobic liquid, such as benzene. Experiments using a polymeric substrate, such as cellulose acetate, will also be attempted.

SPONSOR: TRI General Research

INVESTIGATORS: T. J. Cochrane, Advanced Graduate Student in Chemical Engineering (Courtaulds, Inc. Fellow), H. J. White, Jr., R. H. Wilhelm



Equipment for studying the diffusion of disperse dyes across phase boundaries. The diffusion cell is within the right-hand black box which is an air thermostat. The light source for the spectrometer system lies to the right of the box; readings are taken from the meter in the center.

STRUCTURE AND PROPERTIES OF FIBERS AND FIBROUS MATERIALS

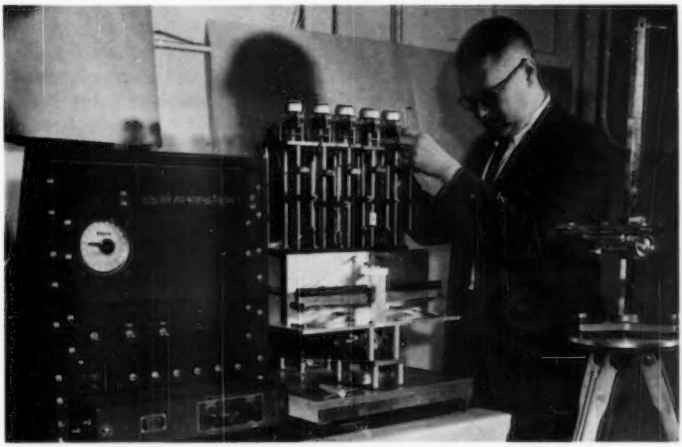
FATIGUE IN TEXTILE FIBERS

In use, textile fibers are subjected to a variety of strains which lead to fatigue, and one of the most important of these is longitudinal strain. For the study of fatigue under such strain a machine has been developed for the cyclic loading of single fibers at substantially constant strain-amplitude (based on initial fiber length). The design of the machine, with its auxiliary electronic equipment, provides means for recording the time-to-rupture of each specimen fiber or for fatiguing a group of specimens for a selected period of time. The record also gives the growth that occurs in each specimen during fatiguing and the extension at rupture. Construction of a six-station apparatus has been completed and study of its performance is underway.

Exploratory studies conducted on a single-station pilot model with samples of continuous-filament rayon reveal wide ranges in the fatigue life of individual fibers within a sample of yarn, especially of the high-crystallinity type. Extensions-to-break of individual fibers, however, were found to lie in a much more narrow range, relatively, though here again the high-crystallinity samples showed the greatest nonuniformity.

SPONSOR: Industry Project on Fatigue in Textile Fibers

INVESTIGATORS: W. J. Lyons, S. Wells, K. Morrison, H. Lambert, H. Knauer



Multiple-station unit for cyclic straining of single fibers. When the unit is in operation, fibers are mounted between top clamp holders (identifiable by round knobs at bottom of vertical rods) and the horizontal black bar which is driven by the motor and scotch yoke (bottom). The small motor-like unit at the top of each station is used to take up increases in sample length resulting from creep.

STUDIES IN THE LOW-EXTENSION REGION OF THE STRESS–STRAIN CURVE

Force–extension measurements made on crimped Acrilan,* viscose-rayon, and nylon fibers in the low-extension uncrimping region, using a highly sensitive electronic balance, resulted in two significant findings. First, it was found that, in all of the fiber types, in the region of very low stresses, the force–extension behavior is similar to that which, in theory, corresponds to a pure unbending process, with no axial extension. Second, when a strained, crimped fiber is allowed to contract to a lower stress level, and is then held at constant extension, a sustained force recovery (evidently associated with crimp in the fiber) is found to occur before relaxation sets in.

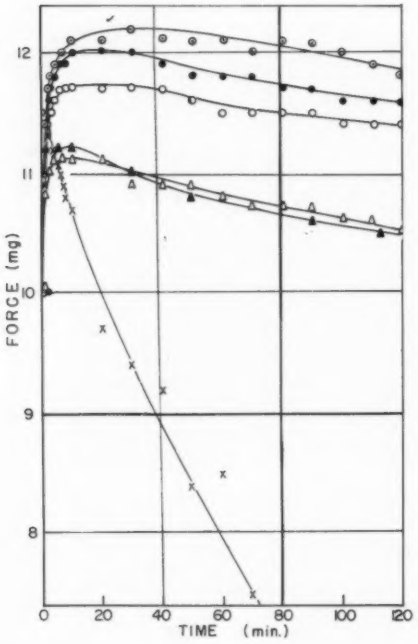
SPONSOR: Industry Project on Crimp in Man-Made Fibers

INVESTIGATORS: W. J. Lyons, A. H. Taylor

*Chemstrand trademark.

THE MECHANICAL BEHAVIOR OF CRIMPED FIBERS

Results were obtained for the load-deflection relations of elastic filaments with arbitrary space configuration and subjected to forces and/or moments applied statically at the ends; the case of a uniformly distributed loading of fixed direc-



Force–time behavior of nylon fibers from texturized yarns under small loads. The fibers have been extended under a larger load and then returned to a load of 10 mg. For the untreated fiber (X) there is a small increase in force followed by a rapid decay. With the fibers from texturized yarns there is a greater increase and a slower decay. The increases result from recovery processes arising from the initial extension under a larger load and rapid return to 10 mg. The long-term decay is a stress relaxation. The presence of crimp in the texturized fiber results in a greater force recovery and a slower stress relaxation.

tion was also investigated. The strain energy of the filament due to bending and torsion was expressed as an integral over the length of the axis; the potential energy of the external end forces was formed similarly. The total energy of the system was minimized by making its variation equal zero, and this variation was carried out subject to an equation of constraint derived from geometrical considerations.

The three equations that resulted from minimizing the total energy, plus the equation of constraint, were sufficient to describe the deformed shape of the filament. Solutions of the general set of four differential equations were obtained for several special cases, including that of a circular helix extended by longitudinal end forces and kept from uncoiling by end moments acting along the longitudinal axis of the helix. The results agreed with those obtained, for this special case and in a different manner, by Holdaway.

SPONSOR: TRI General Research, Office of Naval Research

INVESTIGATORS: R. Chicurel, Advanced Graduate Student in Mechanical Engineering, E. W. Suppiger

REFERENCES: (1) R. Chicurel, "Load-Deformation Behavior of Elastic Filaments with Arbitrary Initial Configuration," Thesis, Princeton University, June 1959

(2) R. Chicurel, "Extension of Elastic Filaments," seminar, Textile Research Institute, May 1959

THE DYNAMIC RESPONSE OF CRIMPED FIBERS

The calculation of the natural frequencies of vibration of filaments is of importance since, as is well known, the response of elastic systems due to arbitrary forcing functions becomes large when the disturbing frequency is equal to the natural frequency of the system. This resonant response means large strains, stresses, energy absorption, and probable material failure. An analysis was thus made to determine the natural frequencies, and the associated model configurations, of crimped fibers. Selected examples of coplanar crimp were examined by energy methods.

For a uniform fiber with arbitrary coplanar crimp, considering bending energy alone, the governing equation was solved exactly for various boundary conditions. When both bending and stretching were included, the resulting equations of motion were simplified by an order of magnitude analysis—and these equations are now being solved by Galerkin's method in conjunction with an IBM 650 digital computer—for selected initial crimps, with the ends fixed.

A preliminary analysis is now being attempted for the dynamic response of filaments, with circular cross-section, whose axes are arbitary space curves initially.

SPONSOR: TRI General Research

INVESTIGATORS: W. D. Freeston, Advanced Graduate Student in Mechanical Engineering, E. W. Suppiger

EFFECT OF FIBER LENGTH ON COTTON FIBER PROPERTIES

Fiber-length distribution has been shown to be an important quality factor in terms of both cotton processability and end-product characteristics. It is, there-

fore, of interest to study the effect of fiber length by measurement of single-fiber mechanical properties from several length groups of one cotton type. In the case of a *G. Barbadense* cotton, fiber strength, elastic stiffness, and resilience were found to increase with length continually, while fiber breaking extension was found to pass through a maximum at approximately the mean fiber length. This study is being extended to other cotton types to determine whether a similar dependence on fiber length exists for all cottons.

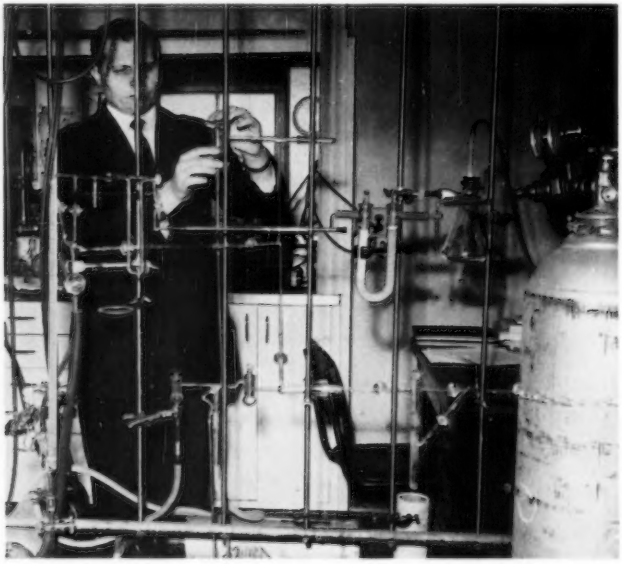
SPONSOR: Industry Project on Cotton Research

INVESTIGATORS: L. Rebenfeld, P. Way

THE RESILIENCE OF CHEMICALLY MODIFIED COTTONS

This project was established to learn more about the quantitative relationships between chemical treatments to modify cotton's resilience, such as cross-linking, and the corresponding changes in physical properties. It has been shown that the resilience of cotton, as characterized, for example, by its elastic-recovery behavior, is important to its utility in "minimum-care" fabrics.

The first portion, which is a major portion of the research program, has been concerned with introducing a quantitatively measurable number of cross-links into the fiber. To achieve this, it has been necessary to investigate reactions of cellulose most likely to lead to products with an unambiguous molecular structure. One problem associated with such work is that of distinguishing true cross-



Vacuum apparatus used for reacting cellulose with sodium in liquid ammonia.

links between cellulosic chains from mere side-groups on the chains; in connection with this problem, it has been necessary to study and modify various methods of appropriate chemical analysis.

Of the various possible reaction systems for this purpose, it has been found that appreciable degrees of cross-linking may be obtained by reacting cellulose with sodium in liquid ammonia to form the sodium cellulosate and then reacting this product with alkyl dihalides. When carried out on cotton fibers in loose-assembly form, the reaction of forming the sodium cellulosate has been found to modify the fiber properties in a way similar to that of slack mercerization. The subsequent cross-linking reaction results in decreases in fiber breaking stress and extension but has little effect on the elastic modulus.

SPONSORS: Industry Project on Resilience of Chemically Modified Cottons and the Foundation for Cotton Research and Education

INVESTIGATORS: J. H. Dusenbury, W. Lobunez, E. Pacsu, E. P. Teulings, A. Revesz

THE PERMANENT SET AND SUPERCONTRACTION OF KERATIN FIBERS

This project was established to learn more about the quantitative aspects of chemical treatments which cause keratin fibers to undergo permanent set and supercontraction. It is planned to investigate treatments whose primary effect is the rupturing of cystine-disulfide bonds or the rupturing of the hydrogen bonds of the protein and to take into account differences in fiber morphology, particularly as these differences are related to fiber crimp. Methods of imparting permanent set and supercontraction to keratin fibers have been studied extensively both in this country and abroad; most recently these studies have been associated with efforts to impart "minimum-care" properties to wool fabrics and have given rise to the development of the "Si-Ro-Set" process in Australia and the "Immacula" process in England. In the program for this project, it is planned to develop data under carefully controlled conditions of fiber stress and/or strain which will yield sound quantitative conclusions concerning the effects of the treatments to be studied.

SPONSOR: Industry Project on the Permanent Set and Supercontraction of Keratin Fibers

INVESTIGATORS: J. H. Dusenbury, E. B. Jeffries

EFFECTS OF CHEMICAL TREATMENTS ON THE RECOVERY FROM DEFORMATION OF WOOL FIBERS AND FABRICS

This program has as its objective a study of the recovery by wool fibers and fabrics from extension and bending, under various ambient conditions, as a function of chemical treatments, particularly internal polymer deposition and cross-linking. A treatment with dimethylol ethyleneurea likely to combine these two effects has been investigated in some detail, and the results obtained are consistent with the view that appreciable amounts of the agent involved are inside the treated fibers and cross-link the keratin polymer chains.

In comparison with the effects produced on cellulosic materials by comparable amounts of the agent, the effects on the wool fiber load–extension curve are relatively small. The first part of the load–extension curve is essentially unaffected by treatment, but the treatment does have the effect of reducing both breaking stress and extension. In this study an inverse relationship has been found between fabric crease recovery and fiber elastic recovery, with the treatment found to decrease dry fabric crease recovery and to have no effect on wet crease recovery.

SPONSOR: International Wool Secretariat

INVESTIGATORS: J. H. Dusenbury, C. J. Dansizer, W. Janicki

MECHANICAL PROPERTIES OF COLLAGEN FIBERS FROM COWHIDE

In this program, the mechanical properties of fibers from cowhides were measured. The effects of location in the hide have been mentioned previously. Tanning causes the fibers to become stiffer, weaker, and less extensible. Tanning causes the hides themselves to become stiffer, weaker, and more extensible. The lack of correlation between fiber and hide properties shows the strong influence of the geometry of the arrangement of the fibers in determining hide properties. In general, fiber properties show less variability between hides than hide properties.

SPONSOR: Agricultural Research Service, U. S. Department of Agriculture

INVESTIGATORS: W. P. Virgin, K. Beurling

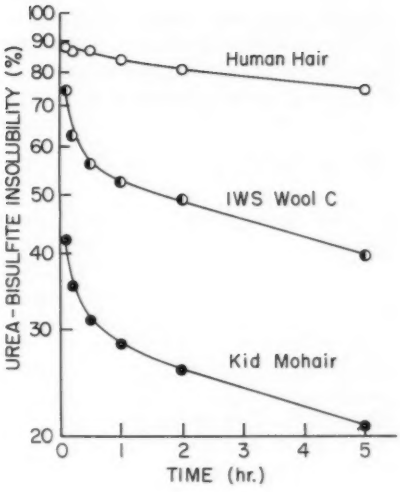
CHEMISTRY OF FIBERS AND FIBROUS SYSTEMS (INCLUDING DYEING AND FINISHING)

CHEMICAL PROPERTIES OF KERATIN FIBERS

Further studies, completed during the year, have been made of the urea-bisulfite solubility test as a means of characterizing the cortical structures of keratin fibers. It has been found that recrystallization of the urea prior to use results in no apparent reagent decomposition occurring during the initial preparation of the reagent and in a lesser extent of decomposition during subsequent storage. The rates of attack of the reagent have been investigated for human hair, crimped apparel wool, and kid mohair. The results indicate the attack to be preferential on the orthocortex and are consistent with earlier views that human hair is a para fiber, that a crimped apparel wool exhibits ortho–para asymmetry, and that kid mohair is chiefly ortho. The studies have also been extended to other fibers, with these conclusions resulting in regard to cortical structures: B.A. fleece and Lincoln wools exhibit ortho–para asymmetry of a radial type, cashmere and vicuna exhibit ortho–para asymmetry of the bilateral type, and alpaca exhibits either bilateral or radial asymmetry, depending on whether it is crimped (Huacayo) or relatively straight (Suri).

SPONSOR: Industry Project on Wool Research

INVESTIGATORS: J. H. Dusenbury, E. B. Jeffries



Urea-bisulfite insolubility of keratin fibers as a function of time of treatment in the reagent at 65° C. As the amount of ortho character of the keratin in the fiber increases, the solubility increases.

PHYSICAL-CHEMICAL STUDIES ON DISSOLVED WOOL

Various methods of breaking the disulfide bonds have been utilized to produce solutions of wool in urea and in alkali. The optical rotations of these solutions have been studied in order to gain insight into the conformations of the polypeptide chains of wool. It is planned to use optical rotation and other properties to study chain conformations and their changes when the environment is altered by adding various reagents and to compare the behavior with that of other proteins.

SPONSOR: TRI General Research

INVESTIGATORS: H. W. Saffer, Second Year Graduate Student in Physical Chemistry, W. Kauzmann

RECEPTIVITY OF COTTONS TO CHEMICAL TREATMENTS

Chemical treatments of cotton to impart certain desirable characteristics have gained great industrial importance. A long-range study was initiated several years ago to determine whether different cottons responded differently to identical chemical treatments. Experiments on mercerization of a large number of cottons indicated that the changes in stress–strain properties as a result of mercerization are not the same for all cottons. Structural parameters, such as fibrillar orientation, govern the response of cotton to mercerization treatments. Recent experi-

ments on cross-linking treatments have shown again that all cottons do not respond in the same manner in terms of changes in fiber stress–strain and resilience properties. The reasons for these differences in response to cross-linking treatments are not completely clear, but it appears that fibrillar orientation is again a most significant cotton-fiber structural characteristic.

SPONSOR: Industry Project on Cotton Research

INVESTIGATORS: L. Rebenfeld, P. Way, H. Wu

THE INTERACTION OF 2-THIOBARBITURIC ACID WITH COTTON

A recent publication [Pan, H. P., Proctor, B. E., and Goldblith, S.A., Textile Research Journal **29,** 425 (1959)] described the use of 2-thiobarbituric acid as a simple diagnostic test for cotton radiation damage. In view of the ever-present problem of cotton heat damage, the use of this reagent as a possible diagnostic test for heat damage was investigated. Initial experiments with laboratory heat-degraded samples have shown that the test is indeed sensitive to heat damage, although the problem of establishing proper standards still remains to be solved. At the same time, it appears that 2-thiobarbituric acid is a most useful reagent for quickly determining the alkali scourable materials in raw cotton. This may prove to be of considerable value to the cotton finishing industry in evaluating both cotton scouring requirements and scouring efficiency.

DILATOMETRIC STUDIES ON THE INTERACTION OF WOOL AND HAIR WITH AQUEOUS SOLUTIONS

Wool and hair suspended in water change their volume when they react with acid or alkali. If the acidic and basic side chains are in a state resembling those of simple amines and organic acids, we would expect that each mole of alkali bound would result in an expansion of about 25 ml. and that each mole of acid bound would give an expansion of 10–11 ml. It is observed that the volume change accompanying acid binding is close to the normal value, indicating that the carboxyl groups of wool and hair must resemble rather closely those of simple acids. The volume change produced on binding hydroxyl ions is, however, only about half the normal value, indicating an environment about the amino groups of hair which differs greatly from the environment of simple amino groups in water. This relatively normal behavior of acid groups and abnormal behavior of basic groups is observed in many soluble proteins, but the abnormal behavior in hair is much more striking than in other proteins. These studies should shed some light on the state of charged side chain groups in wool and hair and the nature of the chain conformation as compared with chain conformations in other proteins.

SPONSOR: TRI General Research

INVESTIGATORS: D. D. Kasarda, Advanced Graduate Student in Physical Chemistry (U.S. Rubber Company Foundation Fellow), W. Kauzmann

SPONSOR: Industry Project on Cotton Research

INVESTIGATORS: L. Rebenfeld, H. Wu

STUDIES ON THE XANTHATES OF CELLULOSE AND METHYL α-D-GLUCOPYRANOSIDE

A method of locating the xanthate groups in carbohydrates by classical means has been established. It was found that the crystalline tribenzoyl derivative of the S-benzyl ester of methyl α-D-glucopyranoside xanthate can be transformed with mercuric acetate to the crystalline monothiolcarbonate derivative which is then quantitatively decomposed by oxidation with hydrogen peroxide to give the known crystalline methyl 2,3,4-O-tribenzoyl-α-D-glucopyranoside in high yield. This result shows that the xanthate group has occupied the carbon-6 position in the starting material.

Application of the method to the S-benzyl ester made from ripened viscose in which the free hydroxyls had been protected with benzoyl blocking groups, and subsequent methylation of the dexanthated product, resulted in a methyl cellulose which was hydrolyzed to D-glucose and its O-methyl derivatives. Chromatographic procedures showed the predominant monomethyl glucose fraction to contain 37% 6-O-methyl, 20% 3-O-methyl, and 43% 6-O-methyl isomers which indicate the actual location of xanthate groups in this commercial ripened viscose. The S-benzyl ester made from green viscose failed entirely to undergo the benzoylation reaction and, therefore, could not be used for similar investigation.

SPONSOR: TRI General Research

INVESTIGATORS: J. J. Willard, Advanced Graduate Student in Organic Chemistry, E. Pacsu

REFERENCES: (1) J. J. Willard, "Location of Xanthate Substituents in Methyl-α-D-Glucopyranoside Xanthate and in Viscose," Thesis, Princeton University, October 1959

(2) J. J. Willard and E. Pacsu, "New Method of Removal of Xanthate Groups in Carbohydrates. The Chemical Structure of α-Methyl Glucoside Xanthate and of Viscose," presented before the Division of Cellulose Chemistry, 136th National Meeting of the American Chemical Society, Atlantic City, September 1959

(3) J. J. Willard, "Chemical Structure of Viscose," seminar, Textile Research Institute, November 1959

NONFIBROUS CONTENT OF COTTON FABRICS

An investigation of methods for determining the nonfibrous content of cotton fabrics has been carried out. The primary objective was the development of rapid methods suitable for Quartermaster Acceptance Testing. The term "nonfibrous content" was interpreted to mean naturally occurring noncellulosic materials, sizes, and nonpermanent finishes. Methods based on the use of dilute sodium hydroxide and sodium borohydride were developed.

The alkaline degradation of cotton cellulose and the reduction of carbonyl groups in cellulose with aqueous sodium borohydride were studied. Cotton was found to be stabilized to alkaline attack by prereduction with sodium borohydride. Dilute sodium hydroxide was found to remove effectively all naturally occurring nonfibrous components (except waxes) and standard sizing materials from cotton yarn and fabrics in 2 hr. without appreciable losses in fibrous content when the

treatment was carried out in a nitrogen atmosphere. Waxes were removed by Soxhlet extraction in aqueous ethanol. Two new methods, designated as (1) the Alkali Method and (2) the Alkali-Borohydride Method, were tentatively proposed to replace the presently existing method (Method 2611.1, Federal Specification CCC-T-191b, January 1956) for the determination of nonfibrous content.

SPONSOR: Quartermaster Research and Engineering Command, Department of the Army

INVESTIGATORS: R. F. Schwenker, Jr., E. Pacsu, R. Turner.

DIFFERENTIAL THERMAL ANALYSIS OF TEXTILE MATERIALS

Differential thermal analysis (DTA) is a method for detecting the chemical and physical changes which occur when a substance is heated and which, by absorption or evolution of heat, result in temperature changes in the substance. These changes in temperature are measured as temperature differences between the sample substance and a thermally stable reference material as both are heated at a constant rate. The DTA curve or thermogram is obtained by plotting these differences as a function of sample (or furnace) temperature and time.

Thermograms in air and in nitrogen have been obtained for cotton, viscose rayon, Fortisan,* cellulose acetate, Arnel,* silk, wool, nylon 66, polyacrylonitrile (Orlon**), polyester (Dacron**), polyethylene, and polypropylene fibers and/or fabrics in the temperature range of 50–550° C. Various modified cellulosic fibers were also studied. New techniques for the application of DTA to textiles have been developed. The data have indicated that reactions such as cross-linking, polymerization, depolymerization, and rearrangement may be distinguishable in the DTA curves of high polymeric materials. Data on moisture content, thermal stability, and first-order transition were also obtained.

*Celanese trademark.
**Du Pont trademark.

SPONSOR: U. S. Naval Supply Research and Development Facility, Clothing and Textile Division and TRI General Research

INVESTIGATORS: R. F. Schwenker, Jr., L. R. Beck, Jr.

REFERENCES: R. F. Schwenker, Jr., L. R. Beck, Jr. "Differential Thermal Analysis of Textile Materials," seminar, Textile Research Institute, November 1959

THERMAL CHARACTERISTICS OF COATED FABRICS

The behavior of textile fabrics under thermal stress may be substantially altered by the presence of compatible textile coatings. Studies on the interactions, including the mechanisms of interaction that may occur at elevated temperatures between fabrics (cotton, nylon, Orlon*) and elastomers used as coatings (butyl rubber, Neoprene W,* Hypalon-20*), have been continued. Detailed knowledge of the reactions and mechanisms of the thermal degradation of the textiles and the coatings separately is required to facilitate analysis of the fabric-coating combinations.

The materials have been studied and characterized by the thermoanalytical technique of differential thermal analysis (DTA). DTA curves, or thermograms,

in an oxidizing atmosphere (air) and a nonoxidizing atmosphere (nitrogen) have been obtained. These curves have been evaluated qualitatively to give an estimate of the nature of the interactions that obtain for each fabric–coating system. Pyrolysis studies have been initiated to obtain data on the products of thermal degradation. A special pyrolysis apparatus has been devised and the pyrolysis behavior of all samples ascertained under dynamic conditions in air and in nitrogen. The results obtained from pyrolysis are being correlated with DTA results to establish the exact nature and degree of interaction and to provide a basis for assignment of mechanisms.

SPONSOR: U. S. Naval Supply Research & Development Facility, Clothing and Textile Division

INVESTIGATORS: R. F. Schwenker, Jr., W. Kauzmann, L. R. Beck, Jr., R. Turner

*Du Pont trademark.

6-THIO DERIVATIVES OF CELLULOSE AND D-GLUCOSE

In the course of an investigation aimed at the introduction of disulfide cross-links in cellulose it has become necessary to study the underlying fundamental reactions on simple model compounds. The 6-tosyl derivatives of D-glucose and methyl D-glucopyranoside, in both the alpha- and the beta-series, have been prepared and their crystalline acetates submitted to the action of various negative groups capable of displacing the tosylate ion. Among these negative groups the iodide, thioacetate, cyanide, thiocyanate, and particularly the sodiumthiosulfato group, $NaOSO_2S^-$, giving rise to the so-called Bunte-salts, were of great interest. From the latter it was possible to prepare the desired disulfides by what appears to be a hitherto unrecognized radical mechanism initiated by heat.

Application of the reaction sequence for production of 6,6′-disulfide cross-linked products to a rayon fabric and to rayon yarn is in progress.

Also, the crystalline 6-thio derivatives of methyl α-D-glucopyranoside will be submitted to biological investigation as possible prophylactic agents against gamma radiation.

SPONSOR: TRI General Research

INVESTIGATORS: L. Lifland, Advanced Graduate Student in Organic Chemistry (The Camille and Henry Dreyfus Foundation Fellow), E. Pacsu

REFERENCE: G. Hebblethwaite, R. F. Schwenker, Jr., E. Pacsu, "6-Thio Derivatives of Cellulose and α-Glucose," presented before the Second Cellulose Conference, Cellulose Research Institute, Syracuse, N. Y., May 1959

CHEMICAL REACTIVITY OF CELLULOSE AND CELLULOSE DERIVATIVES

A basic study has been initiated on the chemical reactivity of cellulose. The objectives of this research embrace the study of reactions to form reactive cellulose intermediates, the preparation and characterization of new cellulose derivatives, and studies on the reactivity of cellulose. Cellulosyl sulfonates have been prepared from wood pulp, cotton, and viscose rayon. The exchange

reactions of the sulfonates involving the sulfonyloxy groups have been studied and evidence for new cellulose derivatives obtained. The preparation and reactivity of metal alcoholates of cotton cellulose is being investigated. Methods for introducing disulfide cross-links into cellulose are also under study.

SPONSOR: The Kimberly-Clark Corporation

INVESTIGATORS: R. F. Schwenker, Jr., E. Pacsu, K. Beurling, H. Wu

CELLULOSE REACTIONS

A study was initiated on the preparation of metal alcoholates of cellulose as intermediates for the preparation of cellulose derivatives. A new method for preparing the true sodium alcoholate of cellulose has been devised by an exchange reaction between simple, low-molecular-weight sodium alcoholates and cellulose in an alcohol medium. The sodium alcoholate of viscose rayon was thus prepared. To confirm the existence of the alcoholate, etherification with methyl iodide was carried out. The distribution and location of the methoxyl groups in the methyl derivatives were determined by qualitative and quantitative paper partition chromatography. Information as to the distribution and placement of the metal substituent (sodium) has also been obtained.

SPONSOR: TRI General Research

INVESTIGATORS: T. Kinoshita, Visiting Research Fellow, R. F. Schwenker, Jr., E. Pacsu

METHYLATION OF CELLULOSE AND CELLULOSE DERIVATIVES

Methylation of carbohydrates may be considered a classical tool of organic chemistry in the determination of structure. Methylation may be accomplished by several means which vary in the degree of severity of reaction conditions. One of the mildest means of methylation involves the use of etherial diazomethane solutions, as no significant alteration in physical structure takes place.

The use of this reagent, therefore, in the evaluation of cellulose accessability appears feasible. Many variables of the methylation reaction must be studied and the reaction conditions properly established. Initial experiments have shown that very low degrees of substitution are achieved, but chromatographic analysis of the reaction product indicates that certain areas of the cellulose, presumably the amorphous regions, are methylated to a considerable extent.

SPONSOR: TRI General Research

INVESTIGATORS: M. Yanaka, Visiting Research Fellow, L. Rebenfeld

FORMATION OF POLYMER-BLEND FIBERS

This program has been concerned with the variations in properties of polymer-blend fibers produced by varying composition, spinning conditions, and drawing conditions. The fibers were composed of cellulose acetate and polyacrylonitrile and spun from dimethylformamide; the properties measured were primarily tensile properties with additional results from x-ray diffraction and microscopic measurement.

Because of the number of independent variables involved (10), it was necessary to formulate workable statistical designs in order to keep the number of experiments within reasonable bounds. Each of the 10 variables has proved to be important, by itself or in a two-factor combination, with respect to one or another of the mechanical properties measured. Attempts are being made to correlate the observed patterns of response with structural features of the fibers.

SPONSOR: TRI General Research

INVESTIGATORS: G. K. Morbey, Advanced Graduate Student in Chemical Engineering (Union Carbide Chemical Co. Fellow), J. C. Whitwell, H. J. White, Jr.

REFERENCE: G. K. Morbey "Formation of Polymer-Blend Fibers," seminar, Textile Research Institute, December 1959

FIBER ASSEMBLIES AND TEXTILE STRUCTURES (INCLUDING MECHANICAL PROCESSING)

EFFECT OF PROCESSING ON CRIMP IN RAYON FIBERS

Studies of processing effects were carried out on samples of noncrimped and a regular-crimp Fibro* rayon. Evaluation of samples from processing stages ranging from raw stock through scoured fabrics disclosed the removal of crimp by processing up to the yarn stage. The effect was most pronounced in the raw stock through roving stages, especially in the regular-crimp material. Weaving, knitting, and scouring appeared to impose new crimp on the fibers. The conclusion is that, in the finished fabrics, the original fiber crimp was masked, and the crimp that was found was predominantly that imposed in the final processing. In general, the processing had no significant effect on the rupture properties of the viscose fibers.

Substantial differences, due to level of crimp, in linear density, modulus, and breaking properties were found in card slivers and rovings. The differences greatly decreased or disappeared in the yarns. At each stage, however, the differences reflected greater cohesion in the structures formed from the crimped fibers. Fabric tests on the scoured, woven, and knit samples failed to reveal any outstanding differences associated with crimp level. In the scoured, woven fabrics, the crimped staple appeared to provide a slightly loftier structure than did the noncrimped, though the two were identical in weight and texture.

The wetting of crimped Fibro fibers from scoured fabrics, followed by oven drying, was found to restore most if not all of the crimp removed in processing. As indicated by the retention of crimp in the cyclic T-2 test, as well as by visual estimates, the crimp recovered by wetting out was as permanent as the original "built-in" crimp.

SPONSOR: Industry Project on Crimp in Man-Made Fibers

INVESTIGATORS: W. J. Lyons, K. Morrison, W. Janicki, A. H. Taylor

*Courtaulds trademark.

CRIMP IN NYLON FIBERS FROM TEXTURIZED YARNS

Evaluations of the crimp in nylon fibers from yarns texturized by various processes were carried out. Five types of texturized nylon yarns, as well as the zero-crimp parent yarn, were evaluated by tests both on fibers taken from the yarns and on the yarns themselves. In general the fibers having the most crimp, as revealed by mechanical-test results and visual estimates, were found to have come from texturized yarns having the higher breaking extensions and loftiness (as indicated by specific-volume measurements). Knitting and scouring were found to tend to reduce the crimp of fibers in texturized yarns. This crimp reduction was not offset by fabric-imposed crimp.

SPONSOR: Industry Project on Crimp in Man-Made Fibers

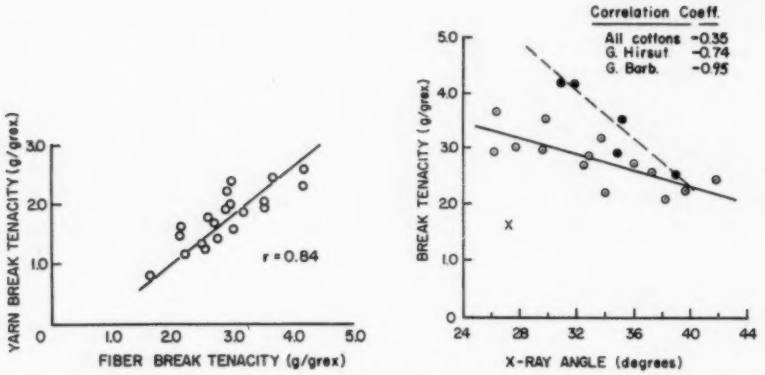
INVESTIGATORS: W. J. Lyons, K. Morrison, W. Janicki, A. H. Taylor

SIGNIFICANCE OF COTTON FIBER EXTENSIBILITY

The development of new cottons with widely different mechanical properties has made necessary careful evaluation of the practical significance of these characteristics. In a detailed study of cotton fiber extensibility, twenty master cottons were examined by bulk and single fiber techniques. The fiber properties were related to structural characteristics of the cotton cellulose, and the transmission of the fiber properties to yarn structures was established. The results of this research clearly indicate that cotton fiber extensibility properties are successfully transmitted to textile yarns and that considerable practical value results from development of new cotton types.

SPONSOR: Agricultural Research Service, U.S. Department of Agriculture

INVESTIGATORS: L. Rebenfeld, P. Way



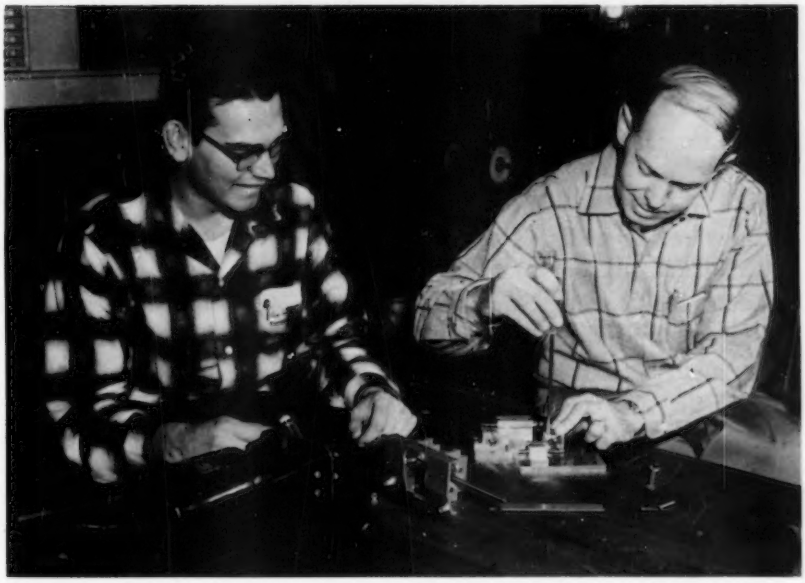
Relationships between yarn mechanical properties, fiber mechanical properties, and morphology for cotton. In the left curve the correlation between yarn and fiber breaking tenacities is shown; in the right, the correlation between fiber tenacity and the x-ray angle. The x-ray angle gives a measure of the angle between the axis of the fibrils within the fiber and the fiber axis.

STUDIES ON NONWOVEN FABRICS

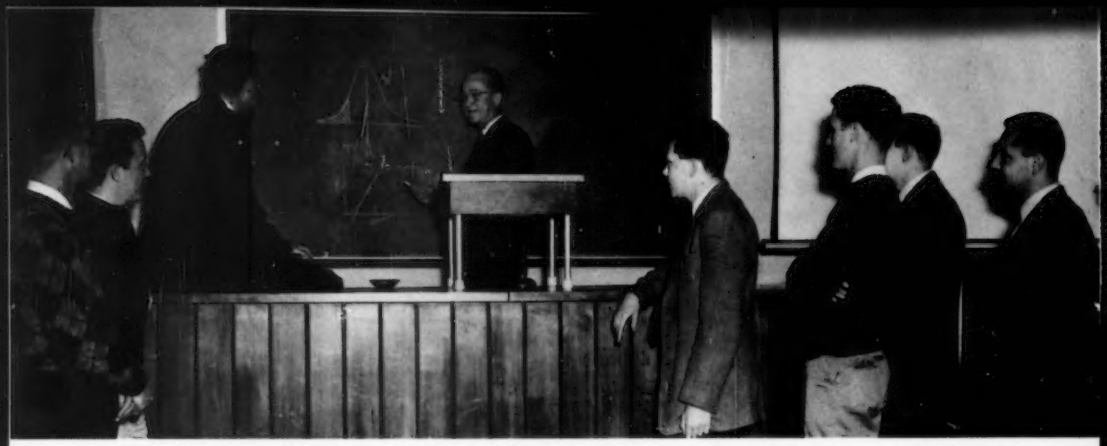
The purpose of this program is an analysis of the effects of a number of the variables in the production of nonwoven fabrics on the properties of the fabrics. Variables under consideration include the type and properties of the fibers used; the type, properties, and method of application of the binder; and the form and method of formation of the fabric. Responses to be measured will include those relating to stress–strain properties and possibly others relating more directly to appearance and appeal. The selection of variables and the design of the experiment are presently under investigation.

SPONSOR: TRI General Research

INVESTIGATORS: G. Bjorge, First Year Graduate Student in Chemical Engineering, J. C. Whitwell, J. H. Dillon



Equipment for projects is often constructed "from scratch" by mechanicians Harry Buvel and Harold Lambert. Here they work on an instrument for fatiguing a fiber by biaxial rotation.



Several predoctoral fellows gather for an informal seminar with Professors Suppiger and Whitwell.

GRADUATE EDUCATION

Research Fellows

Two more Predoctoral Fellows, Ricardo Chicurel and John J. Willard, sustained the final oral examination and thus earned Princeton University's Ph.D. degree in 1959. Dr. Chicurel was our first Fellow in Mechanical Engineering, his doctoral research being carried out under Professor Edward W. Suppiger. He made an excellent record and is now an Associate Professor at Virginia Polytechnic Institute. Dr. Willard majored in organic chemistry and did some very interesting work which establishes the location of the xanthate group in ripened cellulose xanthate. He accepted a postdoctoral fellowship at Cellulose Research Institute, State University College of Forestry, Syracuse University, which permitted him to continue his studies of cellulose. Copies of the doctoral theses of both these men (see Appendix) are available for those who are interested.

Nine Predoctoral Fellows are currently pursuing their work at TRI and Princeton. Of these, six have passed the crucial General Examination (prelims): Donald D. Kasarda and Leonard Lifland in Chemistry; Thomas J. Cochrane, Jr., Graham K. Morbey, and Robert P. Teulings in Chemical Engineering; and William Freeston in Mechanical Engineering. Mr. Henry Saffer has passed the "qualifiers" in Chemistry; thus he is only a step away from the General Examination.

It is quite apparent that we shall soon be able to add several more Ph.D.'s to the ranks of our graduates (36 Ph.D.'s, 2 M.S.E.'s and 4 M.A.'s as of December 31, 1959). It is also abundantly clear that our corps of graduate students will be depleted seriously in 1960.

This prospective "low tide" in number of Predoctoral Fellows at TRI resulted from several factors: (1) last-minute refusals of 1959 Fellowship appointments, (2) unexpected decisions to give up graduate study after the first year, and (3) one failure in the General Examination. Factors 2 and 3 must be considered as unfortunate but essentially of a recurring nature. Factor 1, however, must be attacked by intensifying our efforts to develop a greater number of qualified candidates for fellowships. Dr. Ludwig Rebenfeld, who assumed responsibility for the graduate educational program on January 1, 1960, is leaving no stones unturned in his attempts to solve this problem, and early results of his efforts are encouraging.

Postdoctoral and Visiting Fellows

Our Visiting Fellowship program has continued in 1959, effectively but on a rather small scale. Mr. Tetsuo Kinoshita, graduate of the College of Science of Hokkaido University and sponsored by the Kanegafuchi Spinning Company, concluded a fruitful year of research in October 1959. Mr. Makoto Yanaka began his Visiting Fellowship on September 14, 1959. He is sponsored by the Mitsui Trading Company and is a graduate in Applied Chemistry of the University of Tokyo. Because the organizations sponsoring these men were not TRI members, tuition was paid in each instance and, as in the case with all Visiting Fellows, the Institute supplied only research facilities and supervision. It seems strange that more organizations, particularly TRI member firms, do not participate in this program by which their junior scientists can gain valuable textile research experience at TRI at very modest cost.

Dr. Aldo Busacca continued his interesting work on fiber surface characterization which was initiated in 1958. His Postdoctoral Fellowship was sustained mainly by TRI General Funds. A great deal of interest has been shown in his apparatus and techniques which may well be the basis of a major group project now being discussed. Dr. Busacca's fellowship will terminate in February 1960.

Fellowship Grants

Five Fellowship Grants were made in 1959 by member companies and other interested organizations. The funds thus supplied ($19,250 per year) were of great importance, since they were added directly to our rather hard-

pressed General Program. But, perhaps more important is the fact that these grants are evidence of increasing recognition of the potential value of the TRI program of graduate education. It is gratifying to note that four of these five grants have already been renewed for 1960 and several new grants are under consideration by member firms and independent foundations.

Recipients of Fellowship Grants receive the same stipend and facilities provided other Research Fellows. They are selected with great care, and to be named to one of these fellowships is considered an honor. In 1959 the Fellows thus designated and the grantors were as follows:

Thomas J. Cochrane, Jr.	Courtaulds, Inc.
Donald D. Kasarda	U.S. Rubber Co. Foundation
Leonard Lifland	The Camille and Henry Dreyfus Foundation
Graham Morbey	Union Carbide Chemicals Co.
Robert Teulings	Johnson & Johnson

Advisory Committee on Education

In recognition of growing interest in the Institute's program of graduate education, Chairman Clark suggested that our former Board Committee on Education be supplanted by an Advisory Committee composed principally of educators. This suggestion met with immediate approval of the Board, and the President was able to secure acceptances from the several distinguished educators and scientists listed among the personnel of the Committee given in the Appendix. Continuity with the past Board Committee's actions will be provided by Dean Malcolm Campbell, who served as its Chairman and continues as Chairman of the Advisory Committee. The assembly of the Committee was completed rather late in 1959 and there has not yet been a meeting; this will be a continuing committee, however, and many important matters have already been accumulated for the agenda of its first meeting in 1960.

DISSEMINATION FUNCTIONS

Publications Department

The Publications Department has operated very efficiently in 1959. Dr. Richard K. Toner assumed full responsibility for the Department upon the

retirement of Julian S. Jacobs in May 1959. Dr. Toner continues as Associate Professor of Chemical Engineering at Princeton University.

Miss Candida Frenking continued her effective work as Production Editor, applying her skills to *Textile Research Journal, Institute Membership News,* the *Annual Report,* and other special publications of the Institute. Among the latter was a condensed brochure on the Institute, *TRInformation,* published in 1959. Dr. Toner continued his preparation and editing of *Notes on Research* which form an unbroken chain of progress reports to the Company Membership since June 1949. Beginning in 1960, *Notes on Research* will be sent to all Associate Members (Personal Members associated with Member Companies).

For the first time in the Institute's history, the Publications Department operated with no deficit in 1959. This closure of the long-deplored gap between publications income and expense will be appreciated by those who have been closely associated with TRI over the years.

With the growth of *Textile Research Journal* and the increased number of subscribers each year, there has been a corresponding increase in the demand for back issues. To assist those wishing to complete their files of our publication, we have in the past maintained extensive inventories of *Textile Research* (1932*–44) and *Textile Research Journal* (1945 to date). This has necessitated reprinting various issues as their supply became exhausted. Within the past several years there has been a sharp increase in this exhaustion rate, and in 1958 the cost of reprinting exceeded income received from the sale of back issues. A study of our remaining inventory made it obviously impossible for the Institute to maintain the earlier issues of *Textile Research.* During 1959, arrangements were made with a commercial reprint firm to take over our remaining inventories, together with reprint

*The first two volumes of *Textile Research* (1930–31) consist of mimeographed reports which are not generally available.

Textile Research Journal is mailed to all states, Canada, and 42 foreign nations. Miss Candida Frenking, production editor, prepares the March issue.

Richard K. Toner

rights, of the first fourteen volumes of this Journal. This was done with the understanding that, within a specified time, these volumes would again be available. The Institute will continue to supply back issues of *Textile Research Journal,* subsequent to 1945, as single issues, single volumes, or in miscellaneous runs. In certain instances, due to short supply, sale of single issues or single volumes will be somewhat restricted.

Advisory Committee on Publications

Previous to 1959, the Institute's publications were the province of the Board Committee on Publications. This Committee performed yeoman service in developing a sound policy on *Textile Research Journal* and improving the Journal income situation. Noting that an acceptable policy had been established and that the Publications Department finally was operating on a balanced budget, Chairman Clark suggested that a permanent Advisory Committee be appointed to consider the broader aspects of TRI publications. As with other TRI Advisory Committees, the personnel of this Committee is not necessarily confined to Board members. Dr. Walter J. Hamburger, who has been active in TRI publications affairs for many years, was chosen as Chairman. It will be noted that, in addition to Trustees Hamburger, Bitter, Gardner, Hedberg, and Laxer, the Committee's personnel includes Dr. Elmer Hutchinson, Director of the American Institute of Physics (see Appendix). His counsel, based upon experience with the parallel but much larger publishing program of AIP, should be of great value to TRI. It was decided that the first meeting of the Committee should be deferred to 1960 in order that the first year's operation of the Publications Department with Dr. Toner at the helm might properly be appraised.

Librarian Ann Mansfield (right) distributes over 125 journals of textile research and related sciences to staff members; she is aided by Miss Peggy Faughnan.

Seminars

Fourteen TRI Seminars, organized by Dr. Ludwig Rebenfeld, were held in the Edward T. Pickard Seminar Room during 1959. That the subjects discussed were exceptionally interesting and the speakers able will be evident in examination of the program (see Appendix). Guest attendance was much higher than in any previous year; yet, the capacity of the Edward T. Pickard Seminar Room was not taxed on any occasion. We look forward to the time when there will be standing room only.

It is well to remember that the Seminar Program has a dual function. First of all, it is an attempt to bring important and interesting research findings to the attention of technical men of the textile and allied industries and to elicit informal, unrestricted discussion. Second, but just as important, is the aim of keeping the TRI staff and Research Fellows abreast of textile-scientific developments, within and without the Institute's laboratories. In this connection, it may be noted that five of the 1959 Seminar speakers were representatives of industrial laboratories, three came from other research and educational organizations, three were TRI staff members, and three were TRI Research Fellows.

The essence of TRI Seminars is informality and uninhibited discussion. Thus, no seminar speaker is asked to prepare a manuscript, nor is the discussion recorded. We have made every attempt to explain these principles, but we still receive letters after almost every seminar asking for copies of the "talk." These we cannot supply, of course, and it is hoped that an

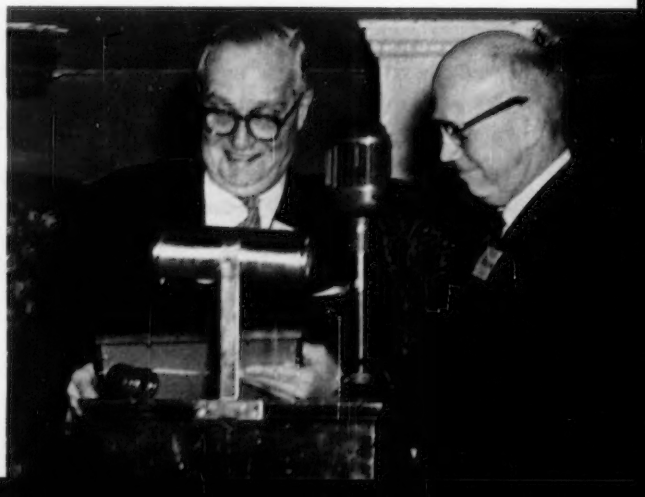
increasing number of textile people will come to realize that the way to profit from a TRI Seminar is to attend in person and participate in the discussion.

Scientific Societies

Activity in professional societies is a healthy thing for any scientist; this is particularly true for TRI staff scientists, since this maintains their status as chemists, physicists, or engineers and keeps them in touch with scientists in fields other than that of textiles, encouraging cross-fertilization of ideas among the various fields of specialization. A glance at the lists of Papers Presented and Staff Professional Activities of the Appendix will suggest that TRI people participate extensively in the programs and operation of their professional associations. It is also true that TRI has been the host to scientific societies on several occasions—The Fiber Society, Inc. at their fall meeting (September 9–10, 1959) and the Polymer and Fiber Microscopy Society (September 25–26, 1959). TRI has agreed to serve as the sponsor of the latter organization.

Annual Meeting

The TRI Annual Meeting has become an established event for textile scientists and research-minded management, and the 1959 meeting was certainly up to standard in all respects. The whole program is reproduced in the Appendix; there is little need to comment on the excellent technical presentations. A high point of the meeting was the address by Sir Hugh Taylor, "Graduate Education in the National Interest," which was followed by his well-deserved citation as an Honorary Fellow of Textile Research Institute. The total attendance was 577 persons.



Sir Hugh Taylor accepts Honorary Fellowship in Textile Research Institute from J. H. Dillon, President, at the 1958 Annual Meeting.

INSTITUTE SUPPORT

The best way to evaluate Institute support in any one year is to consider actual income from each source. The picture thus presented will not coincide with that gained from "rates of income" in the various categories since we are now operating on the "deferred income accounting" basis. Rates of income must be considered in planning future programs but the real "proof of the pudding" is lodged in the "actual income" figures of the accompanying table.

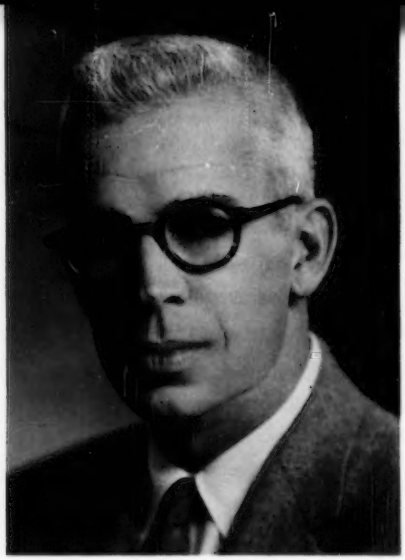
TRI INCOME—1959 vs. 1958

	1959	1958
GENERAL INCOME		
Membership dues	**$110,929**	$106,836
*Less credit to Pub. Dept.	**(13,702)**	(11,102)
Fellowship Grants	**16,367**	12,750
Miscellaneous	**2,600**	3,426
Publications Dept.	**60,822**	50,930
Total General Income	**$177,016**	$162,840
PROJECT INCOME		
Group projects	**142,462**	90,652
Government projects	**75,954**	60,423
Individually sponsored projects	**44,353**	58,984
Total Project Income	**$262,769**	$210,059
Total Income	**$439,785**	$372,899

It is clear from this table that substantial increases in support developed in 1959, as compared to 1958, in all major categories except that of individually sponsored projects. This is not very disturbing, however, as we have not actively sought support of this type.

The over-all TRI support picture at the close of 1959 was indeed encouraging. Disregarding the possibility of a major business collapse and recognizing that continued hard work is required to build TRI activity, the Institute should see further gains in 1960.

*This is a credit to the Publications Department for subscriptions to *Textile Research Journal* furnished to TRI members.



Paul C. Alford, Jr.

FINANCES

The Institute's fiscal performance was much improved in 1959, as indicated in the *Message from the Chairman.* Operating expenditures were at an all-time high but were exceeded slightly by income. Particularly gratifying was the fact that the Publications Department operated "in the black" for the first time. The over-all financial situation, however, was static in that the long-term accumulated deficit remained essentially unchanged.

There are causes for cautious optimism in that trends toward better support of the General Program appear to have been established. If these trends continue and can be accelerated, it should be possible to develop modest operating surpluses and thereby gradually reduce the accumulative deficit. The situation projected for 1960 was sufficiently encouraging for the Board to authorize inclusion of the cost of the staff pension plan in the expense budget. If this optimism proves justified by the appearance of a small operating surplus for 1960, even with this additional load on the expense side, surely the Institute will have made real progress.

Following the close of the Institute's fiscal year on December 31, 1959, Haskins and Sells, Certified Public Accountants, Newark, New Jersey, completed an audit of the Institute's financial position as of that date. There are presented on the following pages a certified balance sheet and a statement of income and expenditures for the twelve-month period then ended.

A copy of the detailed audit may be obtained from the Institute's Secretary-Treasurer at Princeton, New Jersey.

TEXTILE RESEARCH INSTITUTE

STATEMENT OF INCOME AND EXPENSES AND OPERATING DEFICIT

FOR THE YEAR ENDED DECEMBER 31, 1959

Operating Income and Expenses:		
General Income and Expenses:		
Membership dues (less $13,702 allocated to Publications Department)	$ 97,227	
Special contributions (research fellowships)	16,367	
GENERAL INCOME	$113,594	
Less general program expenses—research and graduate education	112,753	$ 841
Special projects (group-supported):		
Income	$142,695	
Expenses	145,752	(3,057)
Other projects:		
U. S. Government:		
Income	$ 75,954	
Expenses	76,105	(151)
Non-government:		
Income	$ 44,353	
Expenses	44,353	–
Publications Department:		
Income	$ 60,822	
Expenses	60,572	250
EXCESS OF OPERATING EXPENSES OVER OPERATING INCOME		($ 2,117)
Other Income		2,367
EXCESS OF INCOME OVER EXPENSES		$ 250
OPERATING DEFICIT—JANUARY 1, 1959		$145,378
Deduct excess of income over expenses, as follows:		
Income	$439,785	
Expenses	439,535	250
REMAINDER		$145,128
Surplus Charge—prior year adjustment relating to deferred income from U.S. Government projects		4,373
OPERATING DEFICIT, DECEMBER 31, 1959		$149,501

The notes to financial statements should be considered in connection with this statement.

TEXTILE RESEARCH INSTITUTE

BALANCE SHEET, DECEMBER 31, 1959

ASSETS

GENERAL FUNDS		
Cash		$ 67,027
Accounts Receivable:		
U. S. Government	$ 24,076	
Other	7,697	31,773
Inventories		6,609
Prepaid Insurance		2,181
Travel Advances, Deposits, etc.		1,825
TOTAL		$109,415
PROPERTY FUNDS		
Cash		$ 7,460
Property–at cost (less depreciation accumulated since January 1, 1956):		
Land and Improvements	$ 17,647	
Buildings and Improvements	213,315	
Laboratory Equipment and Tools	133,388	
Furniture and Fixtures	32,486	
Library	7,150	
Automobile	4,411	
Maintenance Equipment and Tools	3,563	
TOTAL PROPERTY	$411,960	
Less Accumulated Depreciation	70,099	
PROPERTY NET		341,861
TOTAL		$349,321

The notes to financial statements should be considered in connection with this balance sheet.

TEXTILE RESEARCH INSTITUTE

BALANCE SHEET, DECEMBER 31, 1959

LIABILITIES

GENERAL FUNDS	
Accounts Payable	$ 9,732
Unappropriated Textile Foundation Grant	49,060
Unexpended Special Project Receipts	97,168
Unexpended Government Project Receipts	7,353
Unexpended Non-Government Project Receipts	10,731
Deferred Dues, Subscriptions, etc.	84,872
Operating Deficit	(149,501)
TOTAL	$109,415
PROPERTY FUNDS	
Accounts Payable	$ 14,328
Mortgage Payable	22,202
Property Funds Principal (no change during year)	312,791
TOTAL	$349,321

The notes to financial statements should be considered in connection with this balance sheet.

TEXTILE RESEARCH INSTITUTE

NOTES TO FINANCIAL STATEMENTS
FOR THE YEAR ENDED DECEMBER 31, 1959

1. During the year 1959 certain expenses were reclassified from direct charges to administrative expenses, and the method of allocating administrative expenses was revised.

   In 1958, administrative expenses were allocated as follows:

   Other Projects—based upon contractual percentages applied to direct salaries.

   Special Projects—based upon a rate of 100% applied to direct salaries.

   General Program and Publications—charged with the remainder of administrative expenses (after allocation to Special and Other Projects) applied to direct salaries at an effective rate of 91%.

   In 1959, Other Projects were charged on the same basis as previously and a fixed amount of $9,000 was charged to Publications. The remaining administrative expenses were allocated to Special Projects and to the general program for research and graduate education as a percentage of direct salaries, 138% for Special Projects and 127% for the General Program, resulting in total charges to the General Program approximately equal to income from dues and contributions.

2. Income from dues, subscriptions, and fellowships is recorded, with minor exceptions, only as received and deferred to the extent of any prepayment thereof. Project income is accrued only to the extent of the recoverable unreimbursed expenditures applicable thereto, or deferred to the extent of the unexpended balances.

ACCOUNTANT'S OPINION

We have examined the balance sheet of Textile Research Institute as of December 31, 1959 and the related statement of income and expenses and operating deficit for the year then ended. Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

In our opinion, such financial statements present fairly the financial position of the Institute at December 31, 1959 and the results of its operations for the year then ended, in conformity with generally accepted accounting principles applied (except for the change in the method of allocating administrative expenses to the General Program referred to in Note 1 to the Financial Statements) on a basis consistent with that of the preceding year.

Newark, N. J.
March 9, 1960

HASKINS & SELLS
Certified Public Accountants

APPENDIX

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GROUP-SPONSORED PROJECTS

IWS WOOL RESEARCH PROJECT

Period of Support: 2 years beginning October 1, 1958
Total Support Level: $50,000 *Project Director:* J. H. Dusenbury

Sponsor:
International Wool Secretariat (representing wool growers of Australia, New Zealand, and South Africa); technical cooperation by the Wool Bureau, Inc.

Objective:
To study the recovery of fibers and fabrics from extension and bending, under various ambient atmospheric conditions, as a function of chemical treatments, particularly internal polymer deposition and cross-linking.

INDUSTRY WOOL RESEARCH PROJECT

Period of Support: 3 years ended September 30, 1959
Total Support Level: $51,180 *Project Director:* J. H. Dusenbury

Sponsors:
Albany Felt Company
The Barre Wool Combing Company
Deering Milliken Research Corporation
W. J. Dickey & Sons, Inc.
Fabric Research Laboratories, Inc.
Forstmann Woolen Company
Harris Research Laboratories, Inc.
F. C. Huyck & Sons
Rayette, Inc.
J. P. Stevens & Co., Inc.
S. Stroock & Co., Inc.
U.S. Testing Co., Inc.

Objectives:

1. To investigate the sensitivity of various animal fibers to attack by chemical reagents used in wet processing, in order to establish the reasons for the difference among fibers in this respect and to develop tests for predicting fiber performance.
2. To study the effects of chemical treatments and combinations of treatments on fiber chemical and physical properties; in particular, the effects of damage incurred in acid dyeing in the presence and absence of prior treatment with alkali will be determined.

PROJECT ON PERMANENT SET AND SUPERCONTRACTION OF KERATIN FIBERS

Period of Support: 3 years beginning December 1, 1959
Approximate Total Support Level: $75,000 *Project Director:* J. H. Dusenbury

Sponsors:
Albany Felt Company
Bachmann Uxbridge Worsted Company
The Barre Wool Combing Company, Ltd.
Geo. W. Bollman & Co., Inc.
John H. Breck, Inc.
Burlington Industries, Inc.
Colgate-Palmolive Company
Deering Milliken Research Corporation
Harris Research Laboratories, Inc. (The Gillette Company)
Huyck Corporation
Marriner & Co., Inc.
J. P. Stevens & Co., Inc.

Objectives:

1. To investigate the physical and chemical mechanisms by which keratin fibers undergo permanent set and supercontraction.
2. To study the permanent set and supercontraction of keratin fibers which differ greatly in their cortical structures.
3. To study the effects of certain treatments, which cause permanent set and supercontraction in fibers, on the corresponding yarns and fabrics and to attempt to relate the fiber-assembly behavior to that of the constituent fibers.

INDUSTRY COTTON RESEARCH PROJECT

Period of Support: 5 years beginning September 1, 1956
Approximate Total Support Level: $131,000 *Project Director:* Ludwig Rebenfeld

Sponsors:
The American Thread Company, Inc.
Coats & Clark, Inc.
Cone Mills Corporation
Fabric Research Laboratories, Inc.
Joanna Cotton Mills Company
Johnson & Johnson
North Carolina State College, School of Textiles
Pepperell Manufacturing Company
Riegel Textile Corporation
Standard Chemical Products, Inc.
J. P. Stevens & Company, Inc.
United States Rubber Company, Textile Division
United States Testing Company

Objectives:

1. To determine the receptivity of the several strains and varieties of cotton to chemical treatments and its relation to the chemical nature of cottons.
2. To determine the influence of selected fiber properties on processing characteristics and to determine the effect of processing on fiber properties.
3. To establish the influence of fiber characteristics on the processability of cotton by laboratory techniques.

PROJECT ON RESILIENCE OF CHEMICALLY MODIFIED COTTONS

Period of Support: 3 years beginning December 1, 1958

Approximate Total Support Level: $135,000 *Project Director:* J. H. Dusenbury

Sponsors:

American Cyanamid Company
American Viscose Corporation
Burlington Industries, Inc.
Cone Mills Corporation
Deering Milliken Research Corporation
Foundation for Cotton Research and Education
M. Lowenstein & Sons, Inc.
Pepperell Manufacturing Company
Quaker Chemical Products Corp.
Rohm & Haas Company
Standard Chemical Products, Inc.
J. P. Stevens & Co., Inc.
Union Carbide Chemicals Company, Division of Union Carbide Corporation

Objectives:

1. To study chemical reactions leading to improved resilience in cotton, with particular attention to those reactions which produce clear-cut, quantitatively measurable chemical and physical changes within the fibers.
2. To study the relationships between the quantitative measures of these reactions and the physical and chemical properties of the treated fibers, with particular emphasis on the mechanical properties of the cotton fibers and fibrous assemblies.

PROJECT ON CRIMP IN MAN-MADE FIBERS

Period of Support: 3 years ended October 31, 1959

Total Support Level: $97,650 *Project Director:* W. J. Lyons

Sponsors:

American Cyanamid Company
American Enka Corporation
American Viscose Corporation
Canadian Industries Limited
Celanese Corporation of America
The Chemstrand Corporation
Courtaulds (Alabama) Inc.
The Dow Chemical Company
Fabric Research Laboratories, Inc.
B. F. Goodrich Chemical Company

Objectives:

1. To develop improved methods for characterizing crimp of single fibers in raw fiber form and at various stages of processing. This will involve investigation of the effects of single-fiber crimp on the mechanical properties of single fibers, particularly in the low-extension or "uncrimping" region of the fiber force vs. extension curves.
2. To investigate the effects of crimp on fiber processing characteristics, such as spinning efficiency, and to investigate crimp retention through different stages of fiber processing.
3. To evaluate, insofar as they exist, the effects of crimp on estimates of product quality, such as the physical properties of yarns and fabrics from the fibers.

PROJECT ON FATIGUE IN TEXTILE FIBERS

Period of Support: 3 years beginning November 1, 1958
Approximate Total Support Level: $90,000 *Project Director:* W. James Lyons
Sponsors:
Allied Chemical Corporation
American Cyanamid Company
American Viscose Corporation
Celanese Corporation of America
The Chemstrand Corporation
Ste. Chimiotex
Coats & Clark, Inc.
Dunlop Research Centre
E. I. du Pont de Nemours & Co., Inc.
United States Rubber Company, Textile Division

Objectives:

1. To study the influence of static load, stress or strain amplitude, frequency, and other factors in the dynamic stressing of textile fibers on the deterioration in mechanical properties which is recognized as "fatigue."
2. To determine the elementary processes and structural changes, in fibers of representative, important types, that produce or contribute to mechanical fatigue.

PROJECT ON THE CHEMICAL REACTIVITY OF CELLULOSE AND CELLULOSE DERIVATIVES

Period of Support: 2 years beginning March 1, 1959
Approximate Support Level: $32,000 *Project Director:* R. F. Schwenker, Jr.
Sponsor:
The Kimberly-Clark Corporation

Objectives:

1. A basic study of the chemical reactivity of cellulose.
2. The formation of reactive cellulose intermediates.
3. The preparation and characterization of new cellulose derivatives.

GOVERNMENT-SPONSORED PROJECTS

STUDY OF THE INDUSTRIAL POTENTIAL OF RADIOISOTOPIC METHODS IN THE TEXTILE INDUSTRY

Sponsor: U.S. Atomic Energy Commission
Period of Support: 1 year beginning April 1, 1959
Total Support: $14,200
Chief Investigator: Howard J. White, Jr.

RESILIENCE OF FIBERS

Sponsor: Office of Naval Research
Period of Support: 11 years ending May 31, 1961
Total Support: $178,600
Chief Investigator: Howard J. White, Jr.

THERMAL CHARACTERISTICS OF COATED TEXTILE FABRICS

Sponsor: U.S. Navy Supply Research and Development Facility, Clothing and Textile Division
Period of Support: 4 years ending June 30, 1960
Total Support: $69,300
Chief Investigator: Robert F. Schwenker, Jr.

MONOGRAPH ON IMPACT PHENOMENA IN TEXTILES

Sponsor: Quartermaster Research and Engineering Command, Department of the Army
Period of Support: 2 years beginning September 30, 1958
Total Support: $24,874
Chief Investigator: W. James Lyons

RAPID METHODS FOR DETERMINING THE NONFIBROUS CONTENT OF COTTON FABRICS

Sponsor: Quartermaster Research and Engineering Command, Department of the Army
Period of Support: approximately 13 months ending June 15, 1959
Total Support: $15,592.50
Chief Investigator: Robert F. Schwenker, Jr.

A DETAILED STUDY OF COTTON FIBER EXTENSIBILITY AND ITS PRACTICAL SIGNIFICANCE

Sponsor: Agricultural Research Service, U.S. Department of Agriculture
Period of Support: 2 years ending April 8, 1959
Total Support: $40,996
Chief Investigator: Ludwig Rebenfeld

TRI PERSONNEL (as of December 31, 1959)

President John H. Dillon, Ph.D., F.T.I., physicist

RESEARCH AND EDUCATION

Director of Research Howard J. White, Jr., Ph.D., chemist

Group Leaders

Joseph H. Dusenbury, Ph.D., F.T.I., chemist
W. James Lyons, Ph.D., physicist
Ludwig Rebenfeld, Ph.D., F.T.I., chemist
Robert F. Schwenker, Jr., A.B., chemist

Research Associates

Walter J. Kauzmann, Ph.D., chemist
Eugene Pacsu, Ph.D., chemist
Edward W. Suppiger, Ph.D., mechanical engineer
John C. Whitwell, Ch.E., chemical engineer

Senior Scientists

Arthur B. Coe, B.S., microscopist
Walter Lobunez, Ph.D., physical chemist
Stanley Wells, B.A., physicist

Junior Scientists and Research Assistants

Louis R. Beck, Jr., B.S.
Karin Beurling, M.S.
Cornelia J. Dansizer, B.S.
Wanda Janicki, B.S.
Alison Jefford, B.A.
Edward B. Jeffries
Hedwig Knauer, B.S.
Polly K. Way
Kay Morrison, B.S.
Agnes Revesz, B.S.
Elizabeth C. Teulings, B.S.
Rudolph Turner, B.S.
Hong Wu, M.S.

Research Fellows

Gerald Bjorge
Aldo Busacca (postdoctoral)
Thomas J. Cochrane, Jr.
William Freeston
Donald D. Kasarda
Leonard Lifland
Graham K. Morbey
John A. Regalbuto
Henry Saffer
Robert P. Teulings
Makoto Yanaka (visiting)

PUBLICATIONS DEPARTMENT

Richard K. Toner, Ph.D., Director of Publications
Candida F. Frenking, A.B., Production Editor
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PATENTS

Cellulose-Containing Polymeric Materials and Methods of Producing Same, H. J. White, Jr. and David Cates, U.S. Patent 2,868,744 (January 13)

PAPERS PUBLISHED

The Absorption of Dyes by Cellulose Acetate from Nonaqueous Media, Calvin Heit, Mary Moncrieff-Yeates, Ann Palm, Mildred Stevens, and H. J. White, Jr., TEXTILE RESEARCH JOURNAL **29,** 6–12 (January)

Theoretical Values of Dynamic Stress Moduli of Cellulose (Letter), W. James Lyons, *J. Appl. Phys.* **30,** 796 (May)

Practical Applications of Evolutionary Operations, J. C. Whitwell, National Convention Transactions, American Society for Quality Control, 603 (May)

Evolutionary Operations in Chemical Processes, J. C. Whitwell, *Tappi* **42,** 467–473 (June)

Thermal Stability, Flammability, and Melting Characteristics of Textile Substrates, Irvin M. Gottlieb and Louis R. Beck, Jr., *Ann. N. Y. Acad. Sci.* **82,** 724–743 (October)

Development and Comparison of Two X-Ray Methods for Determining the Crystallinity of Cotton Cellulose, J. H. Wakelin, Hester S. Virgin, and Eugene Crystal, *J. Appl. Phys.* **30,** 1654–1662 (November)

The Absorption of Cationic Surfactants by Cellulosic Materials. I: The Uptake of Cation and Anion by a Variety of Substrates, Frederick H. Sexsmith and Howard J. White, Jr., *J. Colloid Sci.* 14, 598–618 (December)

The Absorption of Cationic Surfactants by Cellulosic Materials. II: The Effects Of Esterification of the Carboxyl Groups in the Cellulosic Substrates, Yehezkiel Gotshal, L. Rebenfeld, and Howard J. White, Jr., *J. Colloid Sci.* 14, 619–629 (December)

The Absorption of Cationic Surfactants by Cellulosic Materials. III: A Theoretical Model for the Absorption Process and a Discussion of Maxima in Absorption Isotherms for Surfactants, Frederick H. Sexsmith and Howard J. White, Jr., *J. Colloid Sci.* 14, 630–639 (December)

Critical Factors Involved in Fractionating Cellulose Acetate by Selective Absorption onto Carbon, Bernard Miller and Eugene Pacsu, *J. Polymer Sci.* 42, 97–117 (December)

PAPERS PRESENTED

How Cellulosic Textile Fibers Absorb and Swell, presented by Howard J. White, Jr. at a seminar on Dimensional Stabilization sponsored by the U.S. Forest Products Laboratory, Madison, Wisconsin, January 21

Critical Factors Involved in Fractionating Cellulose Acetate by Selective Adsorption onto Carbon, presented by Bernard Miller and Eugene Pacsu before the Spring Meeting of the ACS, Boston, Mass., February 9

Content and Emphasis in Science Courses, presented by Robert F. Schwenker, Jr. at a joint meeting of Princeton Area Science Education Committee and Princeton Area Science Committee, Princeton, February 24

Evolutionary Operations in Chemical Processes, presented by J. C. Whitwell at the TAPPI Convention, New York City, February 24

Textile Research and the Day-After-Tomorrow, presented by J. H. Dillon at Trenton State College, Trenton, N.J., April 23

Response of Several Cottons to Chemical Treatments, presented by L. Rebenfeld at the Spring Meeting of The Fiber Society, Inc., Fontana Village, N.C., April 29

6-Thio Derivatives of Cellulose and D-Glucose, presented by Eugene Pacsu at the Second Cellulose Conference, Institute of Cellulose Chemistry, Syracuse, N.Y., May 8

Current Trends in Textile Research, presented by Howard J. White, Jr. before the Trenton Section of the ACS, May 12.

Chemical and Physical Differences between Types of Cotton, presented by L. Rebenfeld at a seminar sponsored by the Southern Regional Research Laboratory, Agricultural Research Service, USDA, New Orleans, La., May 18

Structure and Properties of Cotton Fibers, presented by L. Rebenfeld at a seminar sponsored by the Cellulose Research Institute, Syracuse, N.Y., May 25

Practical Problems in Evolutionary Operations, presented by J. C. Whitwell at

the Annual Meeting of the American Society for Quality Control, Cleveland, Ohio, May 27

Theories of Fatigue Failure in Textiles, presented by W. James Lyons at a seminar, Buckeye Cellulose Corporation Laboratories, Memphis, Tenn., June 4

Evolutionary Operations in Chemical Processing, presented by J. C. Whitwell at the Gordon Research Conference on Statistics in Chemistry and Chemical Engineering, New Hampton, Conn., August 24

Effects of Drawing and Skin-Core Ratio on Properties of Viscose Rayon Filaments, presented by J. H. Dusenbury at the Fall Meeting of The Fiber Society, Inc., Princeton, N.J., September 10

New Method of Removal of Xanthate Groups in Carbohydrates. Chemical Structure of α-Methyl Glucoside Xanthate and of Viscose, presented by John J. Willard at the Fall Meeting of the ACS, Atlantic City, N.J., September 17

Fiber Properties and Personalities, presented by J. H. Dillon at the Annual Meeting of The Thread Institute, New York City, October 29

Radioisotope Techniques in the Textile Industry, presented by Howard J. White, Jr. at the Annual Conference, The Atomic Industrial Forum, Washington, D.C., November 4

DOCTORAL THESES

Load-Deformation Behavior of Elastic Filaments with Arbitrary Initial Configuration, Ricardo Chicurel, Department of Mechanical Engineering, Princeton University, June

Location of Xanthate Substituents in Methyl-α-D-Glucopyranoside Xanthate and in Viscose, John Jay Willard, Department of Chemistry, Princeton University, October

NOTES ON RESEARCH*

109. Thermal Stability, Flammability, and Melting Characteristics of Fiber Blends, Irvin M. Gottlieb, January
110. Fiber Surface Analyzer, Part I, Aldo Busacca and W. James Lyons, February
111. Effect of Heat on Cotton Cellulose, L. Rebenfeld, March–April
112. Response of Cotton Fibers to Chemical Treatment, L. Rebenfeld, May–June
113. Mechanical Properties of Feather and Down Fibers, Part I, J. H. Dusenbury, July–August
114. Mechanical Properties of Feather and Down Fibers, Part II, J. H. Dusenbury, September–October
115. Location of Xanthate Groups in Viscose, Eugene Pacsu and John Jay Willard, November–December

*Available only to TRI Company Members.

TRI SEMINARS

Damage of Resin-Treated Cellulose Fabrics, M. D. Hurwitz, Rohm & Haas Company, January 8

Infra-Red Spectra and Hydrogen Bonding in Native Celluloses, C. Y. Liang and R. H. Marchessault, American Viscose Corporation, January 22

Mechanical Properties of Feathers and Down, J. H. Dusenbury, Textile Research Institute, February 19

Optical Bleaches, E. M. Allen, American Cyanamid Company, March 5

Orientation of Crystalline Polymers, R. S. Stein, University of Massachusetts, March 19

Dyeing Hydrophobic Fibers, F. Fortess, Celanese Corporation of America, April 2

Low Temperature X-Ray Studies on Polymers, J. H. Wakelin, Textile Research Institute, April 16

Extension of Elastic Filaments, R. Chicurel, Textile Research Institute, May 7

Seed Hairs and Bast Fibers, T. E. Timell, Pulp & Paper Research Institute, May 21

Cord Stresses in Inflated Tires, H. G. Lauterbach and W. F. Ames, E. I. du Pont de Nemours & Company, Inc., October 22

Chemical Structure of Viscose, John Jay Willard, Textile Research Institute, November 5

Differential Thermal Analysis of Textile Materials, Robert F. Schwenker, Jr. and Louis R. Beck, Jr., Textile Research Institute, November 19

Contractile Mechanisms in Fibrous Macromolecules, Leo Mandelkern, National Bureau of Standards, December 3

Formation of Polymer-Blend Fibers, Graham K. Morbey, Textile Research Institute, December 17

STAFF PROFESSIONAL ACTIVITIES

ARTHUR B. COE, Chairman, Light Microscopy Session, The Polymer and Fiber Microscopy Society meeting, Princeton, N. J., September 25-26

JOHN H. DILLON, President, Society of Rheology; President, National Council for Textile Education; Moderator, American Association for Textile Technology meeting discussion, "New Cellulosic Fibers and their Contribution to Fabric Stability," New York City, February 4; Governing Board, American Institute of Physics; Editorial Board, Journal of Applied Polymer Science; Advisory Panel to the Organic and Fibrous Materials Division, Physics Advisory Committee, American Institute of Physics; Fellow, The Textile Institute; Member, American Panel, The Textile Institute; Fellow, American Physical Society

JOSEPH H. DUSENBURY, Fellow, The Textile Institute; Fellow, American Association for the Advancement of Science; Chairman, New Jersey Chapter of the American Institute of Chemists; Chairman, Arrangements Committee, 36th Annual Meeting, American Institute of Chemists, Atlantic City, N.J., May 6-8; Fellow, American Institute of Chemists

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HOWARD J. WHITE, JR., Governing Council, The Fiber Society, Inc.; Chairman, Program Committee, The Fiber Society, Inc., Fall meeting, Princeton, N. J., September 10-11; Vice Chairman, Gordon Research Conference on Textiles

PROGRAM • 1959 ANNUAL MEETING

MONDAY, March 23, 1959

MORNING SESSION — Chairman, J. B. GOLDBERG

Introductory Remarks

J. B. GOLDBERG, Consultant to the Textile and Allied Industries, and Chairman, TRI 29th Annual Meeting Committee

TRI Research in 1958

Introduction, H. J. WHITE, JR., Director of Research

Cotton Project Research on Fibrillar Orientation

LUDWIG REBENFELD, Group Leader

Wool Project Studies on Fiber Morphology

J. H. DUSENBURY, Group Leader

Other Project and General Research Programs, H. J. WHITE, JR.

Patent Aspects of Research

Presented by GEORGE FREMON, Patent Coordinator
Union Carbide Chemicals Co.

LUNCHEON SESSION — Chairman, J. H. DILLON, Director
Textile Research Institute

Graduate Education in the National Interest

SIR HUGH TAYLOR, President, Woodrow Wilson National Fellowship Foundation

AFTERNOON SESSION — Chairman, WAYNE A. SISSON
Technical Assistant to the Vice President
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American Viscose Corporation

Thermal Effects in Tire Cord Materials

R. S. GOY, J. O. Wood, and F. S. DARUWALLA, Central Research Division
Dunlop Rubber Co., Birmingham, England
Presented by J. O. WOOD

A Third Dimension in Weaving

Presented by ARTHUR R. CAMPMAN, Raymond De-Icer and Engineering Co.

Odor in Resin-Treated Fabrics

Presented by M. EARL HEARD, Vice President in Charge of Research
West Point Manufacturing Co.

TUESDAY, March 24, 1959

SYMPOSIUM ON NEW DEVELOPMENTS AND POTENTIALS OF MELT-SPUN ORGANIC FIBERS

Chairman, S. JACK DAVIS, Manager
Textile Applications Research
The Chemstrand Corporation

MORNING SESSION

*Advancing Frontiers of Nylon and Dacron**
Presented by RICHARD W. NEBEL, Laboratory Director, Textile Research, Textile Fibers Department, E. I. du Pont de Nemours & Co., Inc.

Nylon 6—Current Developments
Presented by GLENN A. NESTY, Vice President—Research
Allied Chemical Corporation

Properties of Kodel Fibers and Fabrics
Presented by E. V. MARTIN, Research Associate
Tennessee Eastman Corporation

LUNCHEON SESSION — Chairman, J. B. GOLDBERG

The State of the Institute
WALTER REGNERY, Vice President
Joanna Cotton Mills Company, and
President, Textile Research Institute

AFTERNOON SESSION

Polyolefin Fibers and Polymer Structure
Presented by VICTOR L. ERLICH, Vice President and Director of Basic Research and Development
Reeves Brothers, Inc.

Saran Polyvinylidene Chloride Fibers and Their Applications in the Textile Field
Presented by LEROY V. JONES, Technical Director
The Saran Yarns Company

PANEL DISCUSSION: S. JACK DAVIS, Moderator

*Registered Du Pont trademark for its polyester fiber.

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